

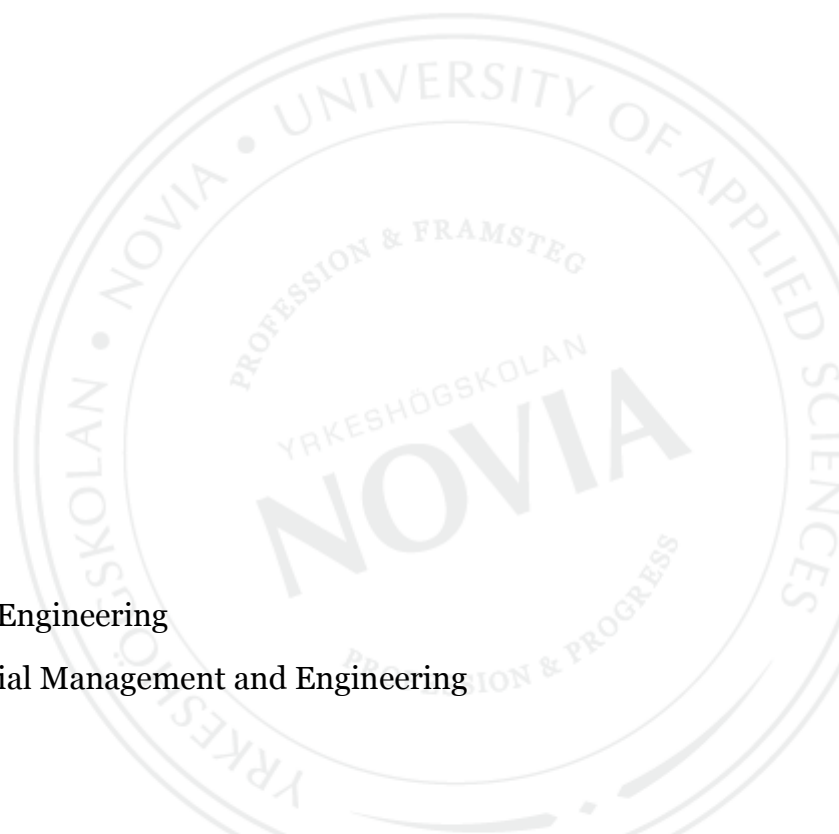
Cost Comparison between Different Joining Options for Cooling Water Pipelines on On-site Installation

Svante Lindholm

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BACHELOR'S THESIS

Author: Svante Lindholm
Degree Programme: Industrial Management
Supervisors: Peter Bergqvist
Mikael Ehlers, Novia UAS

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Summary

The purpose of this thesis is to create a cost comparison on behalf of Wärtsilä Power Plants. In this cost comparison three different pipeline designs for cooling water is compared. There are three different options for the pipeline design, one that is in use, welded, and two new ones, prebended and couplings.

The comparison was done by gathering knowledge from Wärtsilä personnel and suppliers for information and prices for the different options. All information was gathered and then the alternatives were compared to each other. Each option has its own section where the advantages and disadvantages are shown.

The result of this thesis is a cost comparison between the different options. Based on this comparison it can be concluded that the two new options are both better than the original option if the installation is done in Finland. Of the new options the couplings option was better than the prebend option. As for further research this comparison is also applicable to other pipelines on the power plant as long as the required standards are met. The standards are different depending on what kind of pipeline system it is.

Language: English Key words: Cost comparison, pipeline, cooling water

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Författare: Svante Lindholm
Utbildningsprogram och ort: Produktionsekonomi, Vasa
Handledare: Peter Bergqvist
Mikael Ehls

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Abstrakt

Syftet med detta slutarbete var att skapa en kostnads jämförelse. I denna kostnads jämförelse jämfördes olika designer för kylvattenrör. Slutarbetet gjordes på uppdrag av Wärtsilä Power Plants. Det var tre olika alternativ som jämfördes, en som är i användning, svetsnings lösning, och två nya lösningar, för-böjda rör och kopplings system.

Detta gjordes genom att samla in kunskap från Wärtsilä personal och dess leverantörer för information och priser för de olika lösningarna. Den insamlade informationen jämfördes sedan med varandra. Varje alternativ har en del där dess fördelar och nackdelar är visad.

Resultatet av detta slutarbete är en kostnadsjämförelse mellan de olika lösningarna. I denna jämförelse kan det konstateras att de två nya lösningarna är båda bättre än originalet om installationen är gjord i Finland. Lösningen för kopplingar var bättre än det för-böjda röralternativet. För framtida utveckling kan sägas att denna jämförelse kan anpassas till andra rörsystem på kraftverket, så länge alla standarder uppfylls eftersom dom är olika beroende på rör systemets uppgift.

Språk: Engelska Nyckelord: kostnads jämförelse, rör, kylvatten

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Appendix 1.	Matrix for comparison
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TERMS AND ABBREVIATIONS

RFQ – Request for quotation

EPC – Engineering, procurement and construction

SAP – Systems, Applications & Products in Data Processing

Fast track – fast delivery of a ready to launch power plant

TEU – Twenty foot equivalent unit

AWWA – American Water Works Association

WIMCE – cost and time estimation programme

DN – Diamètre nominal/nominal diameter

1. Introduction

Hereunder follows an introduction to the thesis with its objective, delimitations, research plan and the structure for the thesis.

1.1. Purpose

The purpose of this thesis is to show that by changing how the cooling pipeline, from the radiator to the engine, is installed on-site at a power plant it is possible to save in cost and time. This thesis will compare three different options. The first option is the original welding option, which is the one that is being used today. The two new options are the prebended pipes option and the couplings option.

To find out which of the three options is more affordable for the specific project a cost analysis is made. The result may vary depending on where the project is done and where the pipes are manufactured but this analysis can be used as a guideline for which option to use when choosing what type of pipeline to install.

By doing a prebend of a pipe the installation is faster and cheaper, the pipes are easier to clean and the pipes are cleaner because less welding seams also leads to less possible leaking points. But on the downside the prebended pipes are harder to transport since they are more complicated to pack and requires more space, higher installation accuracy and are usually more expensive.

For the couplings the time at the site is even shorter. This option is as easy as the original welded options to transport since it takes up the same amount of space. Although the couplings are much more expensive they make up for it in installation speed.

These two research options are used on projects where the time is of essence. In projects like a fast track project the time is limited and by prefabricating the pipes or using couplings the time at the site is reduced. These alternative options are not used in projects where there is time for welding since that option is usually the cheapest one.

The idea for this project is to show with figures that by prefabricating or by using couplings the total installation cost and the time at the site is lower.

1.2.Delimitation

This thesis is limited to one project, for which the cost comparison has been done. The result of this thesis can then be applied to other projects where the similar options apply. The numbers that have been used in this research originate from quotations from suppliers of the different pipe components. These prices can vary depending on the supplier, but it is important that the quoted pipes have the same standard and requirements as the pipes quoted for in this thesis. All the calculations are made based on one engine, so depending on how many engines the power plant is having, the price has to be roughly multiplied with the amount of engines in the installation. The amount of pipe meters will probably also change since some of the pipelines differ from other, depending on the placement of the engine along with the specific pipeline price for each engine.

1.3.Research plan

To achieve a good result in this thesis I intend to take information from a wide array of sources. I am going to conduct interviews to get information for the three different options and for the prices quotations will be sent to suppliers using the database that Wärtsilä has. The result of these methods is displayed in a matrix and excel sheets where the options can be compared to each other, enabling a decision that is most preferred for the project.

1.4.Thesis structure

In the second chapter I will present Wärtsilä, the company for which I have done my thesis.

The third chapter contains all the theory that I have based all my conclusions and calculations on.

Fourth chapter is the method, which shows how I have done my research to acquire results.

In the fifth chapter is where I present the results of this thesis.

The sixth chapter contains the conclusion and the summary of my thesis.

2. The Company

Wärtsilä is a company, which originates from Finland but is spread across the world. The company has a history stretching back for 180 years, starting from a small sawmill in Tohmajärvi. Nowadays Wärtsilä is split into three sections; Ship Power, Services and Power Plants. (Wärtsilä u.d.)



Figure 1. Wärtsilä corporation structure (Wärtsilä u.d.)

2.1. Wärtsilä in brief

According to Wärtsilä, Ship Power has their focus on the marine market. They provide solutions for ships including machinery, propulsion and manoeuvring. The products they deliver are engines and generating sets, reduction gears, propulsion equipment's, control systems and sealing solutions both for vessels and offshore applications.

Services support-Power Plants and Ship Power installations with solutions for the service and running of the equipment including training. Wärtsilä has also extended its service to other engine brands. Service provides of course maintenance for all Wärtsilä products.

2.2. Power Plants

Wärtsilä Power Plants is a part of the Wärtsilä Corporation, which also contains Ship Power and Services. Wärtsilä is a global leader in both the flexible base load power plant and marine market.

In the year of 2014 Wärtsilä had a total capacity of 55 GW of installed power plants around the globe. The power plants are located in 169 different countries. Power Plants offer three different power solutions: peaking, reserve and load-following power.

The strengths for Wärtsilä's power plants are flexible design, high efficiency and low emission levels. Power Plants had a total NET sale of 1,138 million Euros for the year of 2014 and a total personnel of 978.

Wärtsilä Power Plants has been developed under several generations. They are more reliable and more efficient than large power stations. The engines are excellent at adapting to power peaks. The power plants have multiple modes and can be used as a dynamic complement system to wind or solar power.

Several of the power plants are multi-fuel. Meaning that they can use different kinds of fuels, both liquid and gas, depending on what is more optimal. By doing so the power plants are able to be more feasible for the future where the use of natural gas is expected to grow.

The power plants are also small in size, which enables the placing of them on critical load pockets, like in cities. Also the plants are low in emissions and noise levels, which makes them suitable for placement close to population. (Wärtsilä u.d.)

2.3.EPC Project

EPC stands for Engineering, Procurement and Construction. An EPC project is a project where the seller does all the work and basically hands over the keys to the buyer and then everything is good to go.

In an EPC project the importance is on planning and the right cost estimation so that the quotation of the project is done right and the seller makes profit from the project.

By purchasing an EPC project the customer does not need to interfere in the building of the construction, or any other factor.

This cost comparison is only applicable for projects where Wärtsilä also is in charge of building the power plant. (Project Auditors u.d.)

3. Theory

Hereunder follows the theory that I have used in this thesis. The major part of information in this thesis is taken from suppliers and from interviews with people at Wärtsilä and some suppliers.

The piping for the power plants that Wärtsilä builds are mostly connected with elbows and other parts that require a lot of welding in order for the pipes to be connected. It is a time consuming way but rather cheap since the labour costs usually are low. However, in some cases, depending on the country in which the plant is built, the labour costs can also be high.

The efficiency rate is different depending on the country. In some countries it might take twice the time to complete a task compared to another country where the production is more efficient. Therefore, in order to make for a more cost and time efficient installation of pipes, the pipes can be prebended at the supplier or done with couplings. This will speed up the installation and enable the plant to be built faster. In countries with a lower efficiency rate the costs of the labour is usually low.

In common for all pipes are that the bigger dimensions are harder to handle, because the weight is high. Therefore there are cranes and trucks on-site that do the heavy lifting and assist in lining up the pipes for installation.

In the following chapter is a description of each option and what advantages and disadvantages they have.

3.1. Presentation of solutions

In this thesis there are three different options. One of these options is the standard system that is used for almost all the piping on the site, the first option. This option is the welded pipes option. This means that the pipes are joined together by welding or alternatively if there are flanges, then the flanges are welded to the pipe and then attached to each other.

The second option is called the prebended pipes option. This option focuses on bending the pipes instead of welding them together. A standard pipe length is 6 metres so all the welds cannot be eliminated but the amount of welds can be cut down by more than 50%.

The third option is called couplings option. This option replaces all the welds with couplings instead. The pipes in this option are also a little bit modified, they are grooved in the ends so that the coupling can attach and hold on to the pipe.

All three options can also be combined with each other. The welded and couplings option are two different methods of connecting pipes together, this is an on-site installation. The prebend option focuses on decreasing amount of joints that require on-site installation by prefabricating the pipes by bending them. So the prebend option is possible to combine with the two other options.

3.2. Advantages and disadvantages of welded pipes

This is the original option and the option that has been used the most on the pipelines on power plants built by Wärtsilä.



Figure 2. A welded pipe joint. (Morin u.d.)

Advantages

The installation is somewhat easy; the pipes are lined up and then welded together. The installation is also quite flexible because the pipes can be cut and welded together if needed. The pipes are smaller in size than the prebended pipes and therefore the handling is easier. The skill of welding is a basic industry knowledge and thus that skill can be assumed to be found in every country.

Disadvantages

Installation of a line with several welded seams takes time. One seam on a pipe can take up to several hours to weld. The welding seams require a lot of cleaning in order to not contaminate the pipe line and cause a malfunction of the system. (Mäki-Reini 2015)

3.3. Advantages and disadvantages of prebended pipes

Below follows a more detailed view of the benefits of a prebended pipe design and what disadvantages also occurs when the pipe is prebended.



Figure 3. Prebended pipes. (Uwira u.d.)

Advantages

Wärtsilä have done prebending on projects where the time and money has been of greater importance, such as projects with short delivery time and when the labour costs for the site have been high.

Prebended pipes also require some welding but a lot less compared to normal pipe design. By prebending there are also several other benefits that can be taken into consideration.

By prebending the pipes instead of welding them together there will be less welding seams, which make them cleaner compared to if they would have been welded.

The pipe doesn't need as much cleaning, less seams means the pipe is kept cleaner. Also by having fewer seams the chance of a leakage is lower. By having a faster installation time the installation will be cheaper.

Disadvantages

From production to the site the logistics of the pipe is more demanding. The pipes take up more space and require more planning when they are packed for transportation. When the

pipes are prebended they also require better accuracy when they are installed. The pipe code needs to be written down on the pipe for clarification and to reduce the risk of mistakes.

A prebended pipe is also fitted for the design. This means that if the design needs to be altered, the pipe will be more likely not to fit in in the new system where a normal pipe would be more flexible. However, the risk of a change of order is small. The prebended pipe is also heavier, since there is only one pipe instead of two pipes, as it would be in the two other options, making the handling of the pipe more difficult.

Lastly the price for the production of the pipe is higher. (Kuusisto, Re-routing of cooling water pipeline 2011) (Björk 2015)

3.4. Advantages and disadvantages of couplings

Hereunder follows a more detailed view of the benefits of a coupling pipe design and what disadvantages also occurs when the design is done with couplings. In case that the contractor does not have the knowledge on how the couplings should be installed there is a possibility to receive a half a day training to learn how to install the couplings correctly. This training is done with a video clip. This option is used on firefighting equipment. On the smaller dimensions of the couplings design the couplings are not applied, the pipes are welded instead.



Figure 4. Coupling explained. (Quickcoup u.d.)

Advantages

The couplings method is the fastest way of installing the cooling water pipeline. Every welded seam can be replaced with a coupling making the installation much faster. By using couplings it is also easy to change a pipe or a component that is damaged due to that the coupling is easy to attach and detach.

No hot permit is needed for the installation since no welding is done, that also means that the amount of supervisors is lower.

The durability of the coupling itself is not a problem because they fulfil the standards that are set for the pipes.

There is no need for a torque wrench since the coupling is tightened fully by hand or machine, whatever is preferred or accessible.

Disadvantages

The couplings are expensive to purchase. All of the gaskets might not be suitable for the cleaning procedure that is done when the pipeline is finished, since the washing procedure contains substances that could damage the gaskets. The gaskets need to be of the right type to endure the different cleaning procedures and normal use. Another solution to this is that the gasket is removed during the washing procedure. The gasket has a limited lifespan, since they are made of rubber. They need to be replaced after a specific time depending on the material.

Due to the temperature changes the supports for the pipe needs to be calculated again because of the pipes thermal expansion and contraction. The total weight of the pipeline will also increase, because for each bend there are three components instead of one component in the welded design. The weight increase might lead to a recalculation of the building construction. (Mitts och Hortans 2015)

The gasket in the coupling can be changed to a gasket that is resistant to the washing fluid and acid used. It is important that the right gasket is ordered for the right pipeline and that the installation is done correctly. Therefore if the gasket is to be used in pipes where the pickling procedure is used, they need to be of the right type. (Luhtanen 2015)

3.5. Requesting for a quotation

In this thesis the comparison is done based on the quotations that is received from supplier. Therefore it is of importance that the supplier knows what to include in the quotation.

The RFQ should be as detailed as possible without revealing business secrets. The more details given to the supplier the more information he can use to give a more reliable quotation. Depending on how well you know the supplier you can give different amount of information. There can be suppliers you have done business with during several years as well as the new and untested supplier and thus the amount of information given should be considered.

The information given should contain the following:

- Specification sheets
- Additional technical drawings and pictures, if needed
- Sizes and dimensions
- Material specifications
- Packing requirements, if packing is done by supplier
- Quality documentation

When dealing with a long-term supplier the information given would logically be increased due to ease in production and delivery for the supplier. If there is a large annual order volume from the same supplier you could negotiate better prices.

If you are looking for completely new suppliers you should never settle for only one quotation. At least three quotations should be answered so that you can get the most beneficial order.

When a new supplier has been established, good communication and cooperation is a key to a successful relationship.

When receiving a quotation, it is important to go through it so that all the details are correct and that there are no hidden fees. (China Performance Group u.d.) (Geoffrey 2014)

3.6. Packing and installation procedure

All the pipes are packed into containers at the supplier. Depending on what design that is packed, there might be different amounts of containers needed for all the components. This because the prebend design can take up to double the amount of space when packed. Also for the couplings option there are a little more components packed.

For the prebended pipes each order is a little different from the other. This is because there is no standard of how to pack the prebended pipes. That means that each time an order of prebended pipes are packed, the supplier spreads all the pipes out on the floor and then figures out how the pipes will be packed into the container. A factor that can make this packing procedure even harder is if the pipes are done in a three-dimensional plane, meaning that they have bends that stretch out of the two-dimensional plane. The supplier prefers that all the pipes be bent only in a two-dimensional plane, however, several bends can occur on the same pipe. (Lammi 2015)

For the couplings there are a little more components packed compared to the original option, because for each elbow that would otherwise be welded there are two couplings needed. Included in the container is also two grooving machines, one that is driven by hand and the other that is driven by electricity. (Mitts och Hortans 2015)

3.7. Transportation

The material is transported from Finland to the site, taking approximately five weeks give or take a few days. This is depending on how lucky the transport is on finding a suitable ship that the container can be shipped with to the destination for this project. Transportation time may vary depending on the destination. Into consideration is also taken the customs clearance that might vary depending on destination country.

Table 1. Container size

Length	Width	Height	Volume	TEU	Max cargo weight
20 ft (6.1 m)	8 ft (2.4 m)	8 ft 6 in (2.6 m)	1,4 cu ft (38.5 m ³)	1	21,6 tonnes
40 ft (12.2 m)	8 ft (2.4 m)	8 ft 6 in (2.6 m)	2,7 cu ft (77 m ³)	2	26,5 tonnes

(Emase u.d.)

As can be seen in table 1 above the maximum weight does not differ so much from the 20 feet to the 40 feet container even if the volume is almost double the amount in the 40 feet container. There are also other containers with similar size that allows more cargo weight, but that is not needed for the pipes. The price difference between these solutions is almost the same as the difference in cargo weight, making it much more valuable to use one 40 foot container instead of two 20 foot containers. Assuming that the amount of normal piping would fit into a 20-foot container, the prebended design would fit into a 40-foot container. This means that the price to transport the prebended option is not double the normal cost because the volume is doubled. The cost, for Wärtsilä, to transport a 40-foot container from Finland to Senegal compared to a 20-foot container is only 35% more for the 40-foot container.

When planning the time consumption for transporting the container across continents the only a rough estimation can be made. Time spent on the sea transport and customs clearance is a thing that influences the transportation time. They are factors that are more or less hard to affect, however, the right documentation eases the customs clearance but problems can still occur. (Granberg 2015)

During the transportation it is important to keep the pipes clean and dry. Moist and dirt could get into the container. In order to protect the pipes from rust and other contamination they are greased and a plug is inserted in both ends of the pipe. (Lammi 2015)

Wärtsilä has of course discount prices because they are a frequent transporter.

3.8.Importance of choosing the right supplier

When choosing a supplier Wärtsilä have criteria's that the supplier must fulfil. Wärtsilä has a Suppliers Handbook with information and requirements that they demand from each supplier. Depending on each department there might be specific things that are taken into consideration when choosing the supplier. For the cooling water pipes there are some things that need to be taken into account when choosing the supplier for the pipes and components.

It is preferable that the supplier supplies all the components that are included in the order to make the handling of the order easier and minimizing the risk that a part of that order would be delayed.

3.9.Weight differences between options

In the case that there is a change in pipe design there is probably also a change of weight for the pipes. The couplings option is heavier than the original welding option since, instead of one component that will connect the pipes, there are three components that connect them, two couplings and one elbow component, this leads to a weight increase.

For the prebended option the weight is going to decrease compared to the couplings option, since there is no pipe component, just a pipe that is bent. See calculation below.

If the radiators are on the roof the weight on the roof will increase if the coupling option is used. Therefore the strength of the roof might need recalculation. In some cases the building could be reinforced, but in case the increase is minimal and the maximum allowed weight is not exceeded no further modification is required.

Below is an example for one bend, prebended option compared to the coupling option.

- DN200, prebended = normal pipe weight for the distance that the pipe is bent.
- DN200 bend length is 438mm (Uwira u.d.), weight for 1000mm is 23,80 kg (Wärtsilä u.d.)
- Then the weight for one bend is 10,42 kg

DN200, coupling = one joint/bend requires two couplings and a component (e.g. elbow).

- 2x DN200 Coupling weight = 3,83 kg
- DN200 Elbow weight = 9,92 kg
- Total weight for coupling joint is 17,58 kg (LVI-Dahl u.d.)

Weight difference between these two options for one bend is around 7 kg for DN200 pipes.

As a result the prebended option is lighter than the original option and the couplings option is slightly heavier than the original option, which is 16 kg (Onninen u.d.).

3.9.1. For welded pipes

When choosing the supplier of the welded pipes there is not so much to take into consideration other than that every pipe must fulfil all the standards and that the supplier can provide all the parts for the order.

3.9.2. For prebended pipes

For the prebended pipes there are a four factors influencing on the pipe when it is bent.

The first thing that is of most importance is the bending radius, since there are several different pipe dimensions in one design. The radius on the bend is depending on the machine model that the suppliers have. The suppliers have different machines that they are using and each machine model have a bending radius of their own. Therefore the design needs to be custom made to a certain level, depending on the manufacturer. It is considered that the lower the bending radius the better, since less space is needed for the bend.

For the pipe there is also a S_{min} , a P_{min} and a P_{max} value. The S_{min} value means the minimum value in millimetres that it needs to be in-between two bends in order for the machine to work if there are more than two bends on a single pipe. The P_{min} and P_{max} value means the minimum and maximum value in millimetres that is needed on one of the sides of the bend so that the machine can bend the pipe. In case the pipe need to be shorter, the pipe can be cut after it has been bent in the machine. The standard pipe length for a DN200 pipe is 600 mm so it is preferable that the whole pipe fits into the machine in order to minimize the waste materials. If there is waste material those pipes are sent together with the rest of the material in the container ~~to~~ and can be used on-site if they are needed.

Lastly there is the thickness of the pipe wall. The thicker it is the more pressure it can hold and the more it can be bent. However, with a thicker pipe wall the more force is needed to bend the pipe. Due to this, the bending machines at the supplier are a major factor for the pipe manufacturing and specifications. (Grönkvist 2015) (Uwira u.d.)

An explanation to how the pipes are measured can be seen in figure 5.

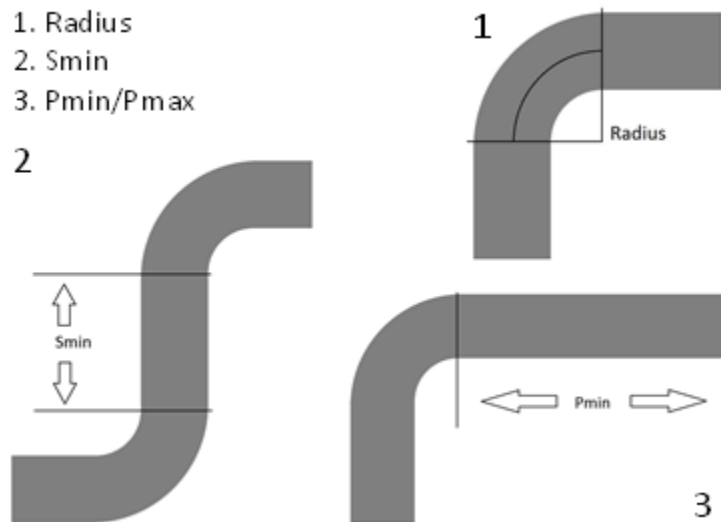


Figure 5. Different bending measurements. (Own construction)

3.9.3. For the couplings option

The suppliers for couplings all have different brands that are used, but all of them look quite similar. For the couplings to be applicable in this system they have to fulfil standards set by AWWA. The standards that are set by AWWA is a standard for grooved and shouldered joints. (American Water Works Association 2011).

One concern regarding the couplings is that the gasket in the coupling will not resist the pickling procedure. Instead there are several different gaskets that can be used. There are acids and alkaline resistant gaskets and other that are usable. For the cooling water pipes there is no pickling procedure and the gasket in them does not need to sustain the acid or alkaline solution. It is important that the request for quotation is sent to the supplier informs what kind of gasket is needed for the pipe. Even though the gasket is small in size it is expensive and time consuming to transport one to the other side of the planet in case that there is a fault in the delivery. Same aspect applies for all components. (Mitts och Hortans 2015)

3.10. Installation procedure

In section 3.10 follows the procedure that is done when the pipeline is installed, from the arrival of the container to the site until it is finalised and ready for operation. This installation procedure is the same for all the options. The only difference is the joining method between the welded option and the couplings option.

3.10.1. Installation

When the containers have arrived to the site and it is time for installation the parts are unloaded and sorted out. If the pipes are prebended they are placed in groups, but all the pipes are kept in the container until installation to protect them from dirt and damage. The pipes are lined up and with the use of cranes or trucks the pipes are moved and lined up for connection. The installation is done from two ends simultaneously, however, the method may vary depending on the contractor. The two starting points are the engine and the radiator; they meet up in the middle. For each option the same thing is done except the joining method that is different depending on if the pipes are welded together or connected with joints. The prebended option does not affect the way the pipes are connected, only the amounts of joints that are needed for the pipeline to be complete.

This is done for each of the pipelines; there are two pipelines for each engine. In some cases there are additional pipelines for each engine in case better efficiency of heat recovery is preferred. When the pipeline is completely installed they are cleaned. (Kuusisto, Expert, Performance and Technology 2015)

3.10.2. Cleaning

All the pipes that are installed on the plant are cleaned. Depending on what purpose they serve they are cleaned differently. Some pipes demand more cleaning than others. In common for all pipes are that they are cleaned from slag and rust by scaling with tools and also grinding the welding seams, and that they are blown with compressed air. If the pipes are greased they need to be washed with an alkaline solution with a water temperature of 80°C for degreasing. For cooling pipes there are four treatments that is done before the pipe is ready for use.

In total there are six different cleaning methods that is used depending on what kind of pipeline it is.

First the pipe is washed with the alkaline solution, this is only done if the pipe is greased.

Second treatment is removing of slag, rust and scaling with tools and grinding the welded seams inside the pipe to receive a smooth surface and prevent contamination.

Thirdly the pipe is then blown with compressed air to remove any leftovers from inside the pipe.

Lastly the pipe is treated by flushing it with water. (Wärtsilä 2014)

4. Method

For the specific information for this thesis I have interviewed people within Wärtsilä. For each solution I have conducted interviews to achieve a good result where as much information as possible is received. I also conducted Interviews to one of Wärtsilä's subcontractor. To receive prices I have contacted Wärtsilä's suppliers.

4.1. Interviews – qualitative research

The people I have interviewed have been pointed out by my supervisor. When I have had an issue that I wanted to find out he named someone who knew more information about it. Once or twice I got redirected to a second source. Questions asked during the interviews were made in advance and were based on the topic for the interview. The interviews were made both in person and over e-mail, whichever was easier to achieve. Language used when performing the interviews was English, Swedish or Finnish depending on what was preferred by the interview subject. The Wärtsilä personnel were quick and eager to answer my questions and it seldom took more than one day for me to receive and answer on my questions.

4.2. Quotations and prices

The prices I have used in this thesis originates from quotations from Wärtsilä's suppliers and information within Wärtsilä for prices for work done by Wärtsilä personnel.

4.3. General comparison

In order to receive an exact time estimation from a contractor on-site there are several factors that are taken into consideration and not only the time that it takes to weld one seam. For all the options there are handling times, lining up times and installation times. I have assumed the handling and lining up times are approximately the same for all the options since the parts are similar in size. But it is on the installation time that time is saved by using another option than the original welding option. Therefore the installation time and the delivery time are the only timelines that are different depending on the option.

When Wärtsilä asks for a RFQ from the contractors, Wärtsilä gives out a form that describes the amount of components, welds, pipe metres etc. in order for the contractor to quote for

the work that is needed. If there is a something that is not included in the quotation and that needs to be done the contractor will do it but will charge extra as a change of order.

(Kivimäki 2015)

5. Results

In this chapter the result of this thesis is presented. A matrix where the prices are compared and a matrix where the time is compared has also been made. These are confidential and therefore a modified comparison is shown in this chapter and the matrix is shown in the appendix. The matrix is a clarification tool to show the differences between the options. For Wärtsilä the results have been handed over in the form of an excel file. The excel file contains several sheets to show how the calculations have been done.

5.1. Confidentiality

Since the numbers that I have acquired are current and used by Wärtsilä, they are considered confidential. Both the prices and the time consumption for the project are confidential. To show the differences between the different options I have decided that the easiest way to express the values is in percentages.

Wärtsilä have annual agreements with their suppliers, which means that they have a discounted price when ordering from them. This discount is received because the volume that Wärtsilä orders is so big so the profit margin for the supplier doesn't need to be as high as if they would sell to a smaller company that purchases a lower volume each year.

The labour times that I have received are confidential because they show the time table for a project.

5.2. Comparison

Of these conclusions it can be stated that there are possibilities to save money by using the prebend or the couplings option instead of the welded option. There are also possibilities to combine the two solutions so that the amount of joints are minimized by prebending and then the joints that are left are connected by couplings, thus leading to a much lower installation time on-site.

The difference in price is shown as if the welded option would be 100 % and the other two options are shown as a percentage of that, e.g. 75 % means that the cost is 75 % of 100 %. This means that if the welded cost is 100 euros the 75 % option is 75 euros.

For the cost from the supplier it is assumed that they charge for the material and the packing of the material and that Wärtsilä will purchase the containers. The contractor price is calculated from Finnish hourly rates.

Hereunder follows two tables with the cost and time comparison of the different options, the difference is shown in percentages compared to the welded option, since the real figures are confidential.

Table 2. Cost comparison (Finland)

	Welded	Prebended	Couplings
Design	100,0%	106,7%	124,4%
Purchasing	100,0%	252,9%	296,6%
Transporting	100,0%	129,1%	100,0%
Installation	100,0%	74,4%	43,2%
Total	100,0%	99,7%	79,5%

(Own construction)

Table 3. Time comparison (Finland)

	Welded	Prebended	Couplings
Design	100,0%	106,7%	124,4%
Delivery	100,0%	200,0%	150,0%
Transporting	100,0%	100,0%	100,0%
Installation	100,0%	74,4%	43,2%
Total	100,0%	95,2%	69,7%

(Own construction)

As can be seen in the both tables the couplings option is around 20% cheaper and around 30% faster than the original welded option. Major factors that affect these values are the on-site installation time, which affects the supervisor price, and the price for the contractor, which affects the installation time through the amount of workers working on the pipeline.

The delivery time is also different depending on the option. This is something that can be tinkered with so that it would be lower, decreasing the total time. The prebended option is faster, but the price for bending the pipes is quite high, leading to a similar price as the welded option.

All these percentages are changed depending on the factors for the on-site country. This means that the labour rate and hourly pay rate are different depending on the country. The factors used here are valid if the installation would be done in Finland. In another country where the hourly pay rate is lower and the efficiency is lower the results would be different.

Below are two tables where the efficiency rate in "Country X" is cut in half and the hourly labour rate half the pay compared to Finland. The amount of work done each week is also higher.

Table 4. Cost comparison (Country X)

	Welded	Prebended	Couplings
Design	100,0%	106,7%	124,4%
Purchasing	100,0%	252,9%	296,6%
Transporting	100,0%	129,1%	100,0%
Installation	100,0%	74,4%	43,2%
Total	100,0%	112,0%	97,2%

(Own construction)

Table 5. Time comparison (Country X)

	Welded	Prebended	Couplings
Design	100,0%	106,7%	124,4%
Delivery	100,0%	200,0%	150,0%
Transporting	100,0%	100,0%	100,0%
Installation	100,0%	74,4%	43,2%
Total	100,0%	98,4%	73,7%

(Own construction)

As can be seen in table 4 and 5, when the labour efficiency rate drops and the hourly pay goes down so does the need for a fast installation. The difference is still visible in the installation speed, but the price for the new options are similar to the welded option. This is something to take into consideration in a fast track project where a quick installation is the key. A few percentages can make the difference depending on if the project is completed on time or not.

From these tables it can be concluded that the couplings option is the best alternative when a short installation time is important.

6. Conclusion

In this chapter follows the conclusion and what the following steps, such as further research, would be.

6.1. Summary

In this thesis I have compared three different solutions, one that is in use, and to new ones that are to be implemented and used on projects where the on-site installation time is crucial to be short. The options compared to each other were the welded option, the prebended option and the couplings option.

The difference for purchasing the different options was big, the welded option being the cheapest and the couplings option the most expensive. Then there was the transportation of the parts from the supplier to the site, where the installation is done. The prebended option takes up to twice the amount of volume when they are packed, because of the bends on the pipe making it difficult to pack.

The options have been compared to each other in order to see which one of them have the fastest on-site installation time and which one of them are the most economical. From the cost and time calculation it can be concluded that by using the couplings option it is possible to save on site costs and time.

In the end there were also additional new options that emerged and could be used alongside the prebend and couplings options in order to make the design even more efficient.

Even though the welded option is the least favourable and welding is the most time consuming way of joining two pipes, it is hard to completely eliminate the welds, since some welding is always needed.

6.2. Problems

In order to achieve a very exact cost comparison between all the options a lot of factors would have been needed to take into consideration. I have done the comparison by comparing a few parts in each solution to each other. Regarding the differences in the installation for the options, I have assumed that the time and handling cost on-site have been the same for each option when comparing the biggest difference in installation time.

Another thing that might change the result are the prices from the suppliers; each quotation had a final date when the price I received was viable. This means that next time a quotations is asked for the price might differ from the one I received. A challenge in this thesis was also to keep down the amount of factors taken into consideration in the cost comparison; factors that did not influence the comparison too much were not taken into consideration.

6.3. Further research

For further research the possibilities to implement prebended and/or coupling options on other pipelines could be investigated. It is proven that time could be saved by changing to either one of these options, time that is valuable when there is a deadline for when the plant must be operational and produce electricity.

In the end a fourth option was presented. This alternative is a further development from the prebended option, but it can also be applied to other options. This option contains the possibility to use a flange with a collar. This method would stretch out the pipe and then attach pipes together with a flange that does not need to be welded but only tightened fully to hold, thus saving one weld seam where the flange would be welded to the pipe. This method requires a gasket in between the flanges. See figure 6 for details.

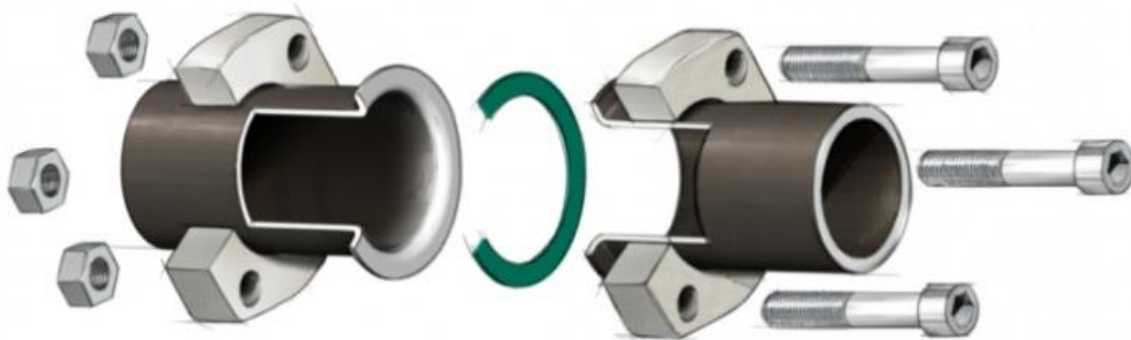


Figure 6. Flare flange system. (GS-Hydro u.d.)

At the end of my thesis project new options and variations increased, and there are a few new options for which a cost comparison could be made to see if these options would be even more economical.

The cleaning procedure could be made easier by adding a protection on the pipe at the supplier so that the pickling is minimal on the pipeline when it is finished on site.

When choosing a contractor to build the power plant, it should be preferred that they have the skill to bend pipes with a small dimension, e.g. sizes below DN50, in order to save in on welds.

6.4.Economic impact

In order to save time on the site installation and thus saving money, money must first be spent in prefabricating pipes or procuring components that are fast to install but expensive to purchase. This would lead to a higher cost and slightly longer production time in the beginning but would save installation time in the end, hence saving money and time on-site. The possibilities to change the way the pipe is installed are many and the possibilities to save on installation costs on-site are big. All the calculations that I have done can also be made in WIMCE when all the parts and information is entered into the system.

As seen in the tables the difference on location is a key to where each option is most valuable. A high priced option is fast to install, but there is a threshold when it is no longer beneficial to have a high installation speed. The costs of a plant being delayed from operation are huge so if the time is important then the coupling option is the best option. Costs are not only measurable in money, but also in credibility. By using couplings the installation time is shortened by 30 % and costs are cut down by 20 % if the installation would be done here in Finland. Abroad the cost difference is decreased in countries where the labour costs are lower, but the time difference is not affected. Therefore by using couplings the installation time is lowered.

6.5.Final conclusion

As a thesis this task was good. I had time to familiarize myself with the task, which felt hard to grasp in the beginning but as time went by I learned more about the task and my confidence grew stronger. Since this was my first work experience at Wärtsilä there was also a lot of new information to take in, such as how the workplace functioned. In my opinion I have learned it well. I have been in contact with a lot of different people within the company when gathering information and this has been rewarding seeing how the system works. The importance of delimitations is something that I have learned to respect. If my thesis would not have been limited at all, the workload would have been huge.

I would like to thank my supervisors Mikael Ehre at Novia University of Applied Sciences and Peter Bergqvist at Wärtsilä for their support. I would also like to thank the people who have helped me and answered my questions when I have been gathering information.

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List of appendices

Appendix 1. Matrix for comparison

	Welded	Prebended	Couplings
Design	Standard design	Requires redesigning, Pipe radius redesigning	Requires some redesigning, insert new components into the system
Production time (ready for transport from final order)	100%	200%	150%
Use	Standard solution	On some cooling pipes	Already on fire water piping
Packing	Packed into a cage and then into the container	Double the amount of containers	Same amount of containers as for welded + coupling components
Transportation	Same time for all	Same time for all	Same time for all
Installation time, time spent joining the pipes together	Welding speed	Less joints so the amount of welds is decreased	The couplings are like building blocks, they are attached and then tightened
Time for one "weld"	DN200 = around 2,5 hours DN100 = around 1,5 hours DN50 = around 1 hour for a seam	Less welds/couplings in total	Coupling solution is five times faster than welding
Component cost for one joint	Elbow DN200 = 100 %		Elbow DN200 = 230 %
Change of order	No problem, cutting and welding in case of change of order	Pipes have spots that allows for modification	Grooving machine on site can groove a pipe that has been modified in case of change of order or leave a pipe that needs on site fitting ungrooved
Possibility for combination	Yes	Yes, joints can be welded or done with couplings, grooving a pipe that is bent could be difficult	Yes, all joints can be
Durability	Pipes must fulfil ANSI/American Water Works Association C606-2004 and EN pipe standards	Pipes must fulfil ANSI/American Water Works Association	Pipes must fulfil ANSI/American Water Works Association C606-

		C606-2004 and EN pipe standards	2004 and EN pipe standards Gasket resistance against pickling procedure Gasket aging, rubber/plastic
Pros	<p>Clear instructions</p> <p>Easy to follow</p> <p>Welding is well known around the world</p>	<p>Less joints in the design</p> <p>Welding joints could be made with couplings instead of welds</p>	<p>No need for a hot permit</p> <p>Half a day education</p> <p>Fast to install</p> <p>Easy/fast to dismantle and repair</p>
Cons	<p>A lot of pickling</p> <p>Time consuming installation</p> <p>Hot permit required</p> <p>Replacing pipes/components time-consuming</p>	<p>Double the amount of containers required</p> <p>Heavy to handle</p>	<p>Different gaskets depending on pipe content</p> <p>Gasket aging durability</p> <p>Half a day education required</p> <p>Grooving machine on site required</p>
Fitting procedure	<p>Paint is removed from welding area (if needed)</p> <p>Pipes are prepared for welding</p> <p>Pipes are lined up for welding</p> <p>Welding procedure</p>	N/A	<p>Pipes are grooved (if needed)</p> <p>Sealant added to gasket (if needed)</p> <p>Pipes are lined up</p> <p>The coupling is installed and tightened</p>